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INDUCED STRESS ON PEARL MILLET vs. HEAD LENGTH

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ABSTRACT

Pearl Millet [Pennisetum glaucum (L.)] is a potentially-productive, high-quality grain or silage crop with a panicle grain head whose head length is highly correlated with grain yield. Our objective was to relate pearl millet head length with three induced stressors: 1. date of planting/soil water stress, 2. herbicide stress, and 3. plant density stress (row width/seeding rate). This research was conducted on a Norfolk sandy loam located on the North Florida Res. and Educ. Ctr., Quincy FL with HGM-100 (W.W. Hanna, Tifton, GA) pearl millet hybrid. Head lengths for 5 May, 15 May, and 15 June plantings accurately predicted grain head yields, but 15 July planting produced less seed and smaller seeds (lb/1000 seeds) with moderately long heads. Tillage systems (no-till and till) had no significant effect on head length. Preplant applications of Dual with 2,4-D or Atrazine, Ramrod alone or with Atrazine significantly (P = 0.05) increased head length in till and no-till treatment. Prowl and

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Atrazine increased head length in till treatment only. The mean head length across row widths for the 6 lb/A seeding rate was significantly shorter than the 2 and 4 lb/A seeding rate. The mean head length across seeding rates for the 5 inch row width was significantly greater than the 15 and 30 inch row width.

INTRODUCTION

Pearl millet is a potentially-productive high-quality grain or silage crop (Burton et al.,1986 and Kumar et al., 1983). It is grown under low-input management conditions (noncrusting sandy soils with little fertilizer and limited water (Payne et al., 1990).

Hattendorf et al. (1988) report that pearl millet had the greatest daily water use rate of all the crops studied. This and the knowledge that pearl millet also had the greatest leaf area index for the same crops suggest that pearl millet has the capacity for deep rootedness, a greater number of roots and/or the attribute for increased rooting density (Davis-Carter, 1989). Timing, intensity and duration of water stress accounted for 70 to 85 % of the variation in pearl millet grain yields within and across years (Mahalakshmi et al., 1985, 1987, and 1988). Critical growth stages receiving stress were flowering and grain filling.

Two preplant herbicides, Pursuit and Accent, were reported to reduce grain yield of pearl millet (HGM-100) 60 and 100 percent of the handweeded check (Wright et al., 1993), but the effect of herbicide stress has not been reported in relation to head length measurements.

The objective of this study was to relate pearl millet induced stress by date of planting/soil water stress, herbicide stress, and plant density stress (row width/seedling rate) to head length which has been used for predicting pearl millet head yields (Pudelko et al., 1993).

MATERIALS AND METHODS

These studies were conducted in 1993 on a Norfolk sandy loam (fine, loamy siliceous, thermic Typic Kandiudult) located on the North Florida Research and Education Center, Quincy, Florida. The soil has a compacted layer located 8 to 14 inches below the surface.

The pearl millet hybrid used in this series of experiments was HGM-100, developed as a grain pearl millet by W.W. Hanna (1991), Tifton, Georgia. Pearl millet seed was no-till planted in a weed fallow field with a Brown Ro-Til implement with KMC planters.

Date of Planting/Soil Water Differences

The pearl millet date of planting study was a split plot design with planting dates as whole plots and components of yield selected within each whole plot as sub-plots (six replications). Planting dates, stages of development, and date of irrigation are shown in Table 1. Plots were eight rows wide (rows were 36 inches apart) and 30 feet long. Seed of pearl millet were planted 3/4" deep at 4 lbs/A (302 667 seeds/A). This resulted in approximately 166,467 plants/A, or 55 % emergence.

Fertilizer (5-10-15 at 500 lbs/A) was applied three days

before planting. Nitrogen was sidedressed to the side of the row at 120 lbs/A at boot stage. Prowl @ 1 qt/A + Atrazine @ 2 qt/A was used for weed control (Wright et al.,1993). Prowl and Atrazine were applied between stage 1 and 2 (10 to 15 days after planting when pearl millet was 3 to 5 inches tall).

Twenty pearl millet heads were carefully selected at random for each replication after black layer formation with concomitant measurements of grain yields, head lengths, and counts of heads per length of row harvested. Pearl millet heads were dried in a greenhouse, and threshed with a clover threshing machine that required 20 pearl millet heads per sample for the threshing operation. Pearl millet heads were measured from top to bottom of panicle (Pedulko et al., 1993).

Little rainfall occurred throughout the early growing season for this experiment. One half inch applications of irrigation were scheduled in response to paucity of rainfall. Rainfall events and amounts are shown in Fig. 1.

Herbicide Study

A herbicide study on pearl millet was conducted on a field where weeds had not been controlled for a year. The field was very weedy. Before it was planted, the field was mowed and divided into two equal parts. One part for conventional tillage-planting and the other for no-tillage-planting. The conventional part was subsoiled at 12 inch depth on 12 May and s-tine harrowed 2 June. The no-till part was sprayed with Gramoxone on 2 June at the rate of 3.0 pt/A primarily for nutsedge control.

Cultural practices common to both tillage systems were: 1. the application of 500 lb/A of 5-10-15 fertilizer June, 2. pearl millet seed treatment with Concep to "safen" herbicide application (particularly Dual), 3. planting on 23 June followed by irrigation with 3/4 inch of water on the day of planting, 4. seeding rate of 4 lb/A in plots 12 feet by 25 feet in 36" rows (plant density of 166,000 plants per acre), 4. band application of 80 lb ammonium nitrate/A two inches to the side of row on 21 July, 5. spraying with Lannate for control of corn earworm on 8 July, and 6. all plots were sprayed with 2,4-D for broad leaf weed control on 16 July.

Seventeen pre-emerge herbicide treatments were applied in different herbicide combinations (Dual, Ramrod, Prowl, Atrazine, and 2,4,-D) on 25 June. Two postemergence treatments of prowl were applied following pre-emerge applications of Atrazine, Ramrod and Prowl in the no-till system only. One hand weeded treatment and two treatments without weed control completed the 22 treatments used in this study (Table 2).

The experiment was a split plot design with tillage systems as whole plots and herbicide treatments as sub-plots. All treatments were replicated four times. Results were subjected to analysis of variance and means were separated using Fishers Least Significant Difference Test at the 5 % level of probability.

Row Width/Seeding Rate Study

The row width-seeding rate study was planted on 28 June. Row

widths and seeding rates used in the study are shown in Table 2. Plot size was 5 feet wide X 25 feet long.

Cultural practices common across all row widths and seeding rates were: 1. application of 500 lb/A of 5-10-15 before planting on 25 June; 2. three applications of ammonium nitrate banded beside row at 50 lb N/A at 5th leaf stage (10 July), boot stage (31 July), and milk stage (27 Aug); and application of Prowl + Atrazine at 1.0 and 1.5 lb/A, respectively on 30 June after planting and before emergence (3 July).

Plant population density (plants per acre and plants per linear foot of row) are shown in Table 3 for each seedling rate and row spacing. Note the uniform plant population density across row spacings (columns) and the increased number of plants within the row as row spacing increases for each seeding rate.

RESULTS AND DISCUSSION

Four pearl millet planting dates are shown in Fig. 1 in relation to maturity dates and rainfall/irrigation events in relation to time. Note the lack of rainfall throughout the season. Total water available from planting to maturity for each planting date (PD) was: PD_1 = 16.4 inches, PD_2 = 19.1 inches, PD_3 = 18.7 inches, and PD_4 = 18.2 inches (Table 1). Physiological stage of development for each planting date is shown in relation to calendar date and day of year.

Pearl millet head lengths are shown for each planting date (columns topped with the same letter are not significant at the 5 % level of significance). Head lengths for 5 May 17 May, and 15

June plantings accurately predicted grain head yields $P < 0.001$) by the equation: $Y = 6.98 + 191.22\ X$ (Pedulko et al., 1993). However, the 15 July planting date produced very little seed. The average number of seeds per 20 non-bird damaged heads was only 105. This may have been related to environmental changes, i.e. reduced length of day, or to paucity of pollinators. Bumble bees which were the primary pollinators for the first three planting dates were essentially absent during flowering of PD_4. It probably wasn't lack of available water (18.2 inches) compared to 16.4 inches for PD_1. Contrary to Mahalakshmi et al. (1988), we found differences in seed size (weight/200 seed) (Fig. 2). Seed size in relation to planting date gives an indication that environment had something to do with grain yield. One would that the 15 July planting date with only 105 seeds per 20 heads should have large seeds like PD_2 or at least seeds the same size as PD_1 and PD_3. Figures 1 and 2 give an indication that grain yield (predicted by head length) and seed size (seed weight/200 seed) are increased by increased water (19.1 inches for PD_2, Table 1) (Mahalakshmi et al., 1987 and 1988) and PD_2 (17 May) may be the optimum planting time during the pearl millet growing season.

Herbicide Study

Tillage systems (Table 2) had no effect on pearl millet head length ($P = 0.05$). Grain yield (bu/A) is an indication of herbicide treatment stress. Figure 4 with herbicide treatment ordered in relation to grain yield shows the lowest grain yields at the left of the X axis and least herbicide at the right of the X axis. In

the till system (Fig. 4A), seed head lengths were significantly longer ($\underline{P}$ = 0.05) with Dual and 2,4-D treatment (trt) at the two lower rates (trt 6 and 7), Ramrod (trt 8 and 9), Dual and Atrazine (trt 12 and 13), Ramrod and Atrazine at the lower rates (trt 13), Prowl and Atrazine (trt 17) than no herbicide application trt (18, 19, 20). In the no-till stem (Fig. 4B) seed head lengths were significantly ($\underline{P}$ = 0.05) longer for Dual and 2,4-D at all rates (trt 5, 6, and 7), Ramrod at all rates (trt 8 and 9), Dual and Atrazine (trt 13 and 14), and Ramrod and Atrazine (trt 15) than no herbicide application in the no-till system. With the exception of trt 14 (Ramrod @ 4 qt/A and Atrazine with oil @ 1 lb/A), Dual and Ramrod increased head lengths and reduced grain yields.

The two post emergence treatments of Ramrod and Atrazine (trt 21) and Prowl and Atrazine (trt 22) had no effect on pearl millet head length ($\underline{P}$ = 0.05).

Row Width/Seeding Rate Study

The effect of pearl millet population density (plants/A and plants/linear foot of row) for each combination row width/seeding rate are shown in Table 3. Those effects on pearl millet head lengths are shown in Table 4. Population density increased in rows from left to right and in columns from top to bottom (Table 4). The mean head length across row widths (Table 4) for the 6 lb/A seeding rate was significantly shorter than the 2 and 4 lb/A seeding rate ($\underline{P}$ = 0.05). The mean head length across seeding rates (Table 4) for the 5 inch row width was significantly greater than the 15 and 30 inch row widths ($\underline{P}$ = 0.05).

CONCLUSIONS

1. Head lengths for 5 May, 17 May, 15 May, and 15 June plantings accurately predicted pearl millet grain head yields ($\underline{P} = 0.05$) with equation $Y = 6.98 + 191.22\ X$.
2. Fifteen July planting date produced very little seed and the seed was small although head lengths averaged over 30 cm long.
3. Tillage systems had no significant effect on head length.
4. Dual and 2,4-D; Ramrod; Dual and Atrazine; Ramrod and Atrazine increased head length in till and no-till systems. The Prowl and Atrazine trt increased head length in the till system only.
5. Post emergence treatments of Ramrod and Atrazine and Prowl and Atrazine had no effect on head length ($\underline{P} = 0.05$).
6. The mean head length across row widths for the 6 lb/A seeding rate was significantly shorter than the 2 and 4 lb/A seeding rates ($\underline{P} = 0.05$).
7. The mean head lengths across seeding rates for the 5 inch row width was significantly greater than the 15 and 30 inch row widths ($\underline{P} = 0.05$).

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LEGEND

Figure 1. Rainfall during the 1993 pearl millet growing season for four planting dates in relation to rainfall amounts and dates of events.

Figure 2. Pearl millet head lengths in relation to date of planting. Columns topped by the same letter are not different at the 5 % level of significance.

Figure 3. Pearl millet see size (weight of 1000 seeds) in relation to date of planting. Columns topped by the same letter are not significantly different at the 5 % level of significance.

Figure 4. Herbicide stress indicated by grain yield (bu/A) in relation to herbicide treatment and length (inches) of till (A) and no-till (B) systems.